VOLUME XVI NUMBER 5 WHOLE NUMBER 122

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED MONTHLY
(*Ten numbers per year*)

May-June, 1922

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WHELDON & WESLEY LTD.
38 GT. QUEEN ST., KINGSWAY, LONDON

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PLATE III.

The Drake University Municipal Observatory, Des Moines, Iowa.

By Courtesy of *Popular Astronomy*.

PLATE IV.

The Entrance to the Drake University Municipal Observatory.
By Courtesy of *Popular Astronomy*.

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DRAKE UNIVERSITY MUNICIPAL OBSERVATORY

BY D. W. MOREHOUSE

THE dedication of the new Drake University Municipal Observatory on November 5th, 1921, was a notable event in the history of Des Moines. If there were no more to the project than the beautiful and altogether unique building situated in an ideal location, there would be sufficient cause for congratulation. However, the purpose of the enterprise gives it distinction. The idea of a Municipal Observatory is probably not indigenous with Des Moines. It has appeared in some form in a few American cities. The oldest and possibly the most authentic claim is made by Cincinnati. Records show that about 1842, the Cincinnati Astronomical Society bought the famous Mitchel Telescope. This instrument was placed in the Cincinnati Observatory, located in the heart of the city. It was later, 1873, moved to Mount Lookout. In 1903 a larger telescope was purchased and additions were made to the building.

At the dedication of the Mitchel Building of the Cincinnati Observatory, Director J. G. Porter referred to the reputation which Cincinnati has acquired of starting new and untried enterprises, citing the Mitchel Telescope among other examples. He pointed out that "Mitchel in procuring for the people of Cincinnati, at that time a western, frontier city, a telescope rivaling the great Pulkova glass, then the largest in the world, justly ranks as the originator of this progressivism. For although the Observatory was not at first a municipal institution, it was nevertheless erected

by and for the people; and the new Mitchel Building designed chiefly for the accommodation of the public, worthily carries out the idea of the illustrious founder of the Observatory".

Oakland, California, also has a Public Observatory established by one of its citizens, Anthony Chabot, and now forming a part of its school system.

The Allegheny Observatory at Pittsburgh, Pennsylvania, founded by Pennsylvania's "Grand Old Man", Dr. John A. Breashear, the famous maker of telescopes, is one of the best known public observatories in the east. He tells the incident that when working in the rolling mills he was permitted to look through a small telescope and it inspired in him a determination to give to the people of Pittsburgh adequate facilities for viewing the heavens. Shortly before his lamented death, April 7th, 1920, Dr. Breashear wrote,* "May I say that while I have been interested in scientific work for nearly half a century and have done my best to bring the beautiful things in science to the comprehension of laymen—yes, to boys and girls, in lectures, etc., nothing outside of my purely educational work has given me so much pleasure as the free department of our Observatory, the realization of a dream of my late childhood. The demand is as great as ever to see the beauties of God's universe, and apart from the scientific side, its high *moral* worth counts every time and all the time".

The above facts have been related that there may be no misunderstanding concerning Des Moines' priority in establishing a Municipal Observatory. I doubt if it can be shown that any other city has planned and erected a public observatory in a public park for the primary purpose of giving to its citizens an opportunity to know the beauty, dignity, and high moral value of Astronomy. It is quite true that after some great soul, such as Mitchel, Chabot, Lick or Breashear, has established and demonstrated the civic value of a public observatory, then the municipality or state has supported it, but Des Moines took the initiative.

Some quotations from a few letters just received will indicate the light in which our city is seen by others. From Ottawa, Canada, comes the greeting,

"I extend my hearty congratulations to the city of Des Moines

*In a private letter to C. A. Chant. See this JOURNAL, Vol. 13, p. 301, 1919.

for the liberal and progressive spirit manifested in the founding of an observatory supported by a municipality. May the example of Des Moines be followed by other cities, especially by those that have a university in their midst."—Dr. Otto Klotz, Director of Dominion Observatory, Ottawa, Canada.

"I heartily congratulate the city of Des Moines on the installation of a municipal observatory. I have been pushing the idea of a municipal observatory for several years. On November 21st I am to lecture before the College Club in Chicago and am to put in some propaganda on a municipal observatory."—S. B. Barrett, Yerkes Observatory, Williams Bay, Wisconsin.

"I heartily congratulate all concerned in the building of the Drake University Municipal Observatory. It is in every way such a splendid achievement. The cooperation between University and city which it symbolizes, is one of the finest things about it. Oakland, as you know, has the Chabot Observatory as a part of its school equipment, but this is exclusively a city enterprise. Berkeley has its student observatory, but this is exclusively a university institution. Your observatory belongs to University *and* city and hence should hold the interest of both as well as serve both. You are all heartily congratulated."—Dr. Robert G Aitken, Lick Observatory, California

Dr. George E. Hale, Director of the great Mt. Wilson Solar Observatory at Pasadena, California, writes, "Hearty congratulations on the initiation of this admirable plan."

The architecture of the building was given more than usual consideration. Two of our leading firms of the city co-operated most effectually in giving to it more significance than is usually found in a building of this character. Its design presented a problem consisting of elements different from those usually confronting an architect. From the architectural point, our first desideratum was to use such features as would indicate that various ancient nations had contributed to the science of Astronomy. Realizing that only a few could be indicated, it was necessary to use those features with discretion in order to obtain a harmonious result, and as architecture is a conventional art, they must be so combined as not to interfere with the general design.

The building is a massive structure of gray bedford stone and the architecture is classic of the severe Grecian type. As one approaches the building, a sun dial is seen directly in front of the main entrance, thus leading the observer by an easy and natural step to reflect upon the importance of the sun to our planet. On six stone panels of the pilasters, on either side of the door, the signs of the zodiac, carved by hand, attract the eye and further direct the mind to consider the relative position of the earth, sun and surrounding firmament. The historical significance of these signs are of great interest and their origin of great antiquity. The top unit of each pilaster is a Greek Corinthian capital which suggests the contributions which Greece made to the arts and sciences. Carved in Roman letters on the lintel is "DRAKE UNIVERSITY MUNICIPAL OBSERVATORY" and directly above this is the familiar bas relief of the winged sun with attendant cobras, used so frequently by the Egyptians on their architectural monuments. On either side of this carving are two dates indicating the age of the building, the one on the west is the Roman date, J.E. 6633, indicating in astronomical lore the Julian epoch and the one on the east, 1920 A.D. is the common Roman name for the year of our Lord. Thus in review before our minds passes the ancient Chaldean, Persian, Egyptian, Greek and Roman civilizations, each of which contributed its part to the science to which this building is dedicated.

From a mechanical point of view, the building is also worthy of note. It has acquired the name of the "honor job" in Des Moines. It seems as if each workman took special pride in contributing all that his art could give to this historic project. The stone-work is especially fine, as all observers admit. A hollow space is left between the outer and inner walls throughout the entire building, thus doing away with a feature which is usually troublesome in a stone building, that is, of moisture penetrating the walls and affecting the decoration. The building is fireproof. There is a very complete basement containing public rest rooms, a fine photographic room, a room designed for a seismograph and an automatic oil-burning heating plant. Owing to the structure of the walls mentioned above, these rooms are as dry as if they were above ground.

On the ground floor the main entrance is into a beautiful rotunda. The conventional representation of our solar system is depicted in marble in the sky blue mosaic floor. The suspended ceiling is dome shape and gives a realistic representation of the celestial sphere. The decoration was given considerable thought. It is a sky blue and blends most beautifully with the surroundings.

Opening from the rotunda to the west is the transit and clock room. On the east is a delightful office while to the north is the gem of the entire building, a public lecture room and library. Extending around the walls of this room are racks containing a most interesting collection of photographic transparencies through which light shines giving a very fine representation of the celestial objects as seen through the telescope. The book cases are of quartered oak in flat finish. The walls are a greenish buff.

The observatory room is just above the rotunda. The telescope is mounted on re-inforced concrete beams resting on the extra heavy stone wall and insulated from possible vibration by compressed cork. These are the only points of contact between the telescope and the building. The interior walls of the observing room are of pressed brick, a soft shade of gray. The lights are recessed, allowing free movement of the observing chair and giving an indirect method of lighting. The dome is eighteen feet in diameter and covered with copper. This makes a beautiful exterior effect, especially in the fall when the various coloured trees are reflected in the variegated colors of the oxidizing copper. There is thus afforded a strikingly appropriate home for the graceful and remarkably efficient nine-inch telescope.

Extending around the exterior of the observing tower is a balcony with an iron balustrade, opening into the observatory by four doors and on to the roof of the lecture room, which is finished with promenade tile and gives an admirable opportunity for entertaining large groups of people with naked eye observations.

The equipment of the observatory consists of a nine-inch Warner & Swasey equatorial with optical parts by the John A. Breashear Company; a five-inch photographic doublet, a nine-inch photographic lens of 120 inch focal length and a standard spectroscope, all by the same firm; a transit instrument by an

English firm, chronograph, chronometer, sextants, and in short, practically all of the usual apparatus used in Astronomy.

The observatory is open to the public without charge, on Monday and Friday evenings from 7.30 to 9.00. They are entertained by the staff with lectures, explanations and direct observation through the telescope. Wednesday evenings are reserved for clubs and public schools by appointment. The observatory has been open for one month and we have entertained something over six hundred people during this time. The interest seems to be growing and the attitude of the people is extremely gratifying.

Drake University,
Des Moines, Iowa.

NOTE ON THE MANUFACTURE OF TELESCOPE DISCS IN AMERICA

By Donald E. Sharp

HERETOFORE, the manufacture of telescope discs has been confined to the optical glass works of Europe. This has been true not because of the inability of American scientists to cope with the difficulties to be encountered in manufacturing these discs, but to the fact that we in this country had never been presented with an opportunity to carry on the necessary research. The world war brought such an opportunity, for it became imperative to manufacture tons of optical glass during war times, for fire control and other instruments; and it was only natural that at the close of the war experimentation was continued with the idea in mind of making America truly independent of foreign shores as far as optical glass was concerned.

Soon after the signing of the Armistice, research was begun at the optical glass factory of the Spencer Lens Company of Buffalo, on the manufacture of large objective discs. Such rapid progress was made that twelve-inch objective discs were soon readily obtainable. The demand, however, at that time seemed to be principally for reflector discs, and therefore, the manufacture of these was also begun.

The method finally worked out for making reflector discs consisted of pouring sufficient glass from a regular melting pot into a suitable mould. The glass had then to be cooled properly, so that it might not break due to the temporary strain of cooling, and also that the permanent strain be symmetrically distributed and reasonable in amount.

The thickness of a reflector disc is usually at least one-sixth of the diameter. It is, therefore, quite evident that discs of large diameter will be tremendously heavy and bulky to handle. Moreover, the difficulty of annealing a block of this nature increases as the square of the thickness of the glass. The initial cooling

rate for a disc two inches thick would be one-fourth that for a one-inch thickness. It is, consequently, obvious that for a large disc accurate mechanical means of regulating temperatures is required. Two different types of furnace were used for the annealing: An electric furnace of the resistance type, and an ordinary gas-fired furnace. Each of these is capable of producing satisfactory results.

Experiments in the manufacture of a twenty-two-inch reflector in the electric furnace were successful in May of 1921, although an earlier attempt with the same equipment had resulted in failure. Previous to this time gas furnaces had been used for the annealing process, but had been considered impractical because of the difficulty of controlling the temperatures. Several attempts were then made to turn out a forty-inch disc, and it soon became evident that the equipment then at hand was not sufficient to permit the annealing of these large discs.

The annealing schedule for a disc of borosilicate glass eight inches thick and forty inches in diameter calls for a constant temperature of 464° C. for seven days. As a factor of safety, it was considered best to double this time and hence to hold the glass for fourteen days at the above temperature. The cooling should, theoretically, proceed as designated by the following schedule, which is according to the research carried out by Adams and Williamson* of the Geophysical Laboratory:

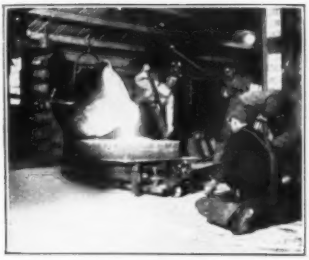
Initial cooling rate				-	0.24° C.	per	hour	
Cooling rate after			10°	drop,	0.29° C.	"	"	
"	"	"	20°	"	0.36° C.	"	"	
"	"	"	30°	"	0.46° C.	"	"	
"	"	"	40°	"	0.60° C.	"	"	
"	"	"	50°	"	0.80° C.	"	"	
"	"	"	60°	"	1.08° C.	"	"	
"	"	"	70°	"	1.48° C.	"	"	
"	"	"	80°	"	2.04° C.	"	"	
"	"	"	90°	"	2.83° C.	"	"	
"	"	"	100°	"	3.96° C.	"	"	

Maximum cooling rate 6° C per hour.

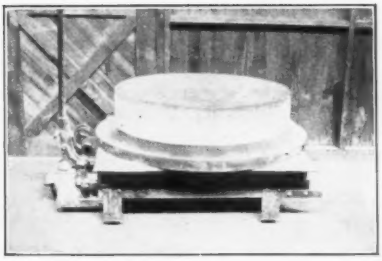
This schedule allows the completion of the annealing in about

* *Jour. Franklin Inst.*, *190*, 597-631 and 835-870 (1920).

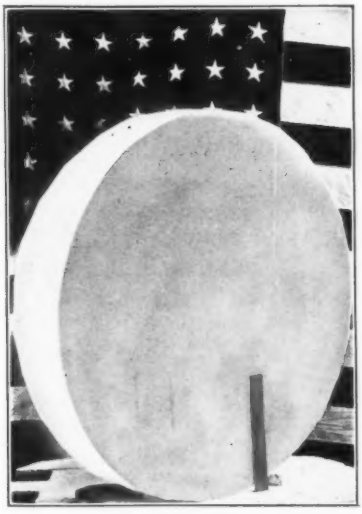
PLATE V.



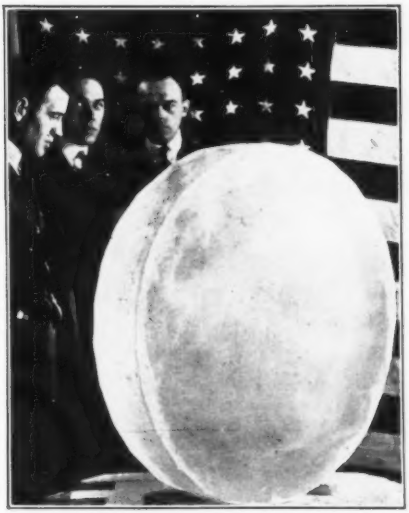
The Casting of the Disc.



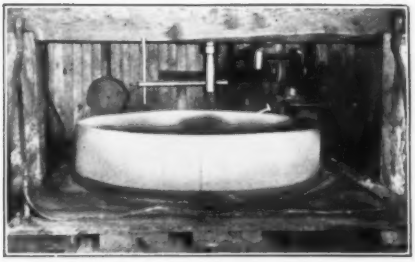
An Annealed Disc lying in Mould.



An Annealed Disc, standing on Edge.



Disc for 40-inch Reflector, standing on Edge.



Large Disc Polished.

three weeks time. It should be noted, however, that the cooling rate given above represents not the average rate but the actual rate at a particular time. It is necessary that the rate gradually increase according to the schedule outlined, but it should not at any particular moment increase above that given by the schedule.

A slower rate than that given by the schedule was consequently used, so that the actual time taken in annealing was about six weeks. After several unfortunate experiences with the automatic instruments, the author's associate in the work, Mr. Walter H. Rising, a chemist of considerable experience in optical glass making, volunteered to assume the responsibility of the equipment during the night. He, therefore, had an apartment fitted up near the annealing furnaces, where he might be called instantly if the night foreman noticed any difficulty in the operation of the machines.

Shortly before this time, the gas furnace, which had been discarded as useless, was restored and redesigned. An automatic valve operated by a thermostat was provided, and a trial of this equipment was made along with a trial of the electric furnace. The furnaces were cooled to room temperature in December of 1921, and after grinding and polishing the two forty-inch discs, they were tested for strain. The results obtained in the gas furnace exceeded the most optimistic expectations, for the disc was extremely well annealed. The one made in the electric furnace was not so good, however.

An interesting improvement in the performance of reflecting telescopes is made possible by selection of the glass. It is well known that the change of figure of a mirror due to change of temperature is a disadvantage in the use of this type of telescope* To eliminate rapid changes in temperature mirrors are usually protected by heat-insulating chambers. It is the expansion of the glass with temperature increase which causes the difficulty and if it were possible, the obvious remedy would be to use a glass which would not expand. Unfortunately this is impossible, but on the other hand the expansion coefficient may be reduced to less than one-third that of ordinary crown. This should operate favourably on the elimination of change of figure.

* See this JOURNAL, *14*, page 195, 1920, "The Optical Parts of the 72-inch Telescope."

Of the two forty-inch discs recently completed, the poorer one was discarded, but the better one was shipped to McDowell of Pittsburgh, who is working it down to size for the new telescope of the University of Arizona. The clear aperture of this glass will be thirty-seven inches, and the instrument will bear the distinction of being the first large all-American telescope.

The details of the processes in the manufacture of large reflector and refractor discs according to American methods will be described in the literature in the very near future.

Spencer Lens Co.,
Optical Glass Plant,
Hamburg, New York.

NOTES ON THE EARLY EVOLUTION OF THE REFLECTOR*

By Louis Bell

THERE is some tradition of reflecting telescopes in classical times, probably groundless save as the ancients had concave mirrors and these, if of fairly long focus, would present to the eye an enlarged image of a distant object.

The first suggestion that a mirror might be used instead of an objective seemed to have come from Mersenne about the middle of the seventeenth century in a letter to Descartes. The idea did not appeal to the latter and the matter was dropped. The first actual reflecting telescope was designed by James Gregory, who published an account of it in his "Optica Promota" in 1663. In this he described the rather elegant construction which still bears his name, a perforated parabolic mirror with an elliptical concave mirror placed beyond its focus and returning an erect image to the ocular through the perforation.

The next year Gregory started Reive, a well-known London optician, at making a 6 foot telescope. This failed on account of inability to get the necessary figure, largely owing to the fact that Reive tried to polish his mirrors on cloth, never a satisfactory material for accurate figuring. It is possible that Gregory had better luck later, for there is a well-defined tradition that he died from a stroke of apoplexy in 1675 while showing to a group of students Jupiter's moons through one of his own telescopes. Certainly Robert Hooke presented a passable example to the Royal Society at its meeting February 5, 1673-4.

Now enters upon the scene the biggest figure of the period in science, Isaac Newton, then a young man who had just discovered the dispersion of light. A great speculative philosopher and mathematician, he was neither a practical astronomer nor a par-

*From the *Proceedings of the American Academy of Arts and Sciences*, February, 1922, with the author's permission.

ticularly good experimenter, and failed to discover the difference of relative dispersion in refractive media by the inexcusable blunder of raising the refraction of the water with which he was comparing glass by loading it with sugar of lead, and then jumping at the conclusion that all substances varied equally both in refraction and dispersion.

In other words he assumed without real investigation that the quantity which we now know as ν was a constant for all substances.

Just how this singularly maladroit piece of experimentation leaked out is unknown, although the fact is stated in the most positive manner both by Sir David Brewster, Newton's admiring biographer, and by Sir John Herschel. It is not unlikely that the fact got abroad at Cambridge in Newton's later years, and was passed along to Sir William Herschel. Certainly, as one of Newton's later apologists naively suggests, the fact was not recorded in Newton's "Opticks."

Be that as it may, it was the kind of thing for which a second-year student in physics would get a wigging which would linger long in his memory, but a blunder with a great name behind it carries far, and in this case it put off for a couple of generations the discovery of the principle of achromatism.

Following his error, Newton gave up all idea of an achromatic lens, and turned his attention to reflectors, apparently being unacquainted with, or entirely disregarding, what James Gregory had done before him. Newton had taken to the country on account of the plague, and only about 1670 did he apparently begin to revolve in his mind a reflecting telescope. It was 1672, January 11th, when he presented to the Royal Society a small model of his preferred form of reflector, which is still in the possession of the Society.

This little model had an aperture of about 1 in. and focal length of about 6 in., and magnified some 38 diameters. Newton was able, he says, to detect with it the moons of Jupiter and the horns of Venus, both feats which can be accomplished with the very slightest of optical aid, providing the magnification is anywhere near that which Newton used. But here again Newton gave notable evidence of his unpractical experimenting, clever though he was.

He had firmly fixed in his mind the entirely erroneous idea that a spherical mirror was quite good enough for the purpose, even when an aperture of F/6 or F/8 was used, believing that the trouble with the long telescopes of the day was almost entirely their chromatic aberration. This was partly true, but the spherical aberrations would have been equally bad save for the very narrow aperture employed.

This error would certainly have brought Newton to grief had he attempted a telescope of any perceptible size, and in fact there is some evidence that this actually happened. On January 25th, just two weeks after his model was displayed, the minutes of the Royal Society note that: "There was produced a reflecting telescope 4 feet long of Mr. Newton's invention which, though the metaline concave was not duly polished, yet did pretty well, but was under charged. It was ordered to be perfected against the next meeting."

At the next meeting the following: "The 4 foot telescope of Mr. Newton's invention was produced again, being improved since the last meeting. It was recommended to Mr. Hooke to see it perfected as far as it was capable of being." So far as the annals record it never again appeared on the scene.

While it was not definitely stated by whom this telescope was made an entry of March 1st of the same year in the *Journal de Sçavans* definitely ascribes this 4 foot telescope to Newton, although the account is rather vague. It would look, therefore, as though Newton himself, or some of his friends, had tried out his invention on a larger scale, and had fallen into exactly the trouble that might have been expected.

Perhaps Newton's aversion to the paraboloid, of which he knew perfectly well the properties, may have been partly due to the fact, as stated in one of his letters, that there is no strictly geometrical method of grinding it. About the same time Hooke proposed to stamp up the specula out of silver and before the end of the year he was working on a 15-inch mould for a speculum of 10 feet focal length, of which nothing has since been heard.

Meanwhile enters upon the scene the personage known in the histories of science as "Cassegrain, a Frenchman." A communication from M. DeBercé to the Royal Society describes his in-

vention and gives a very rough sketch of it. This was a translation of a letter sent by DeBercé to the Academy of Sciences from Chartres, and read at the séance of April 16, 1672. DeBercé says that this invention had been communicated by Cassegrain to him some three months previously, and how much before this time Cassegrain had been working on the problem will probably never be discovered. At all events the Cassegrainian telescope was disclosed to others than the inventor at substantially the same time as Newton's and was certainly an independent invention, although one letter to the Royal Society vigorously berates the Frenchman for stealing "Our Newton's" thunder, and explains how an ingenious friend of the writer is making a still further improvement on Cassegrain's form by using a flat secondary speculum.

Newton's comment on DeBercé's letter plainly shows that he did not enjoy a rival in the field, for it is somewhat discouraging in tone and incidentally his specific criticisms were consistently wrong, as for instance he had the erroneous idea that speculum metal reflects much better at 45° incidence than at normal incidence, whereas in fact the difference is too small for even its sign to be distinguished with certainty. It is the irony of time that the Cassegrainian form is the one which has survived in the greatest instruments of the present time.

The writer is glad to be able to drag "Cassegrain, a Frenchmen," from something of the obscurity in which he has been veiled, introducing then, Sieur Guillaume Cassegrain, sculptor in the service of his glorious Majesty Louis Quatorze, modeller and founder of statues for the decoration of the king's gardens at Versailles.

In 1666 he cast a bust of the King, after Bertin's model, for which he received 1,200 livres, and for the next twenty years or thereabouts made also many replicas from the antique, including groups like the Laocoön, receiving payments from the Royal Treasury for his artistic services well into the year 1684, at which time we lose sight of him. He is believed to have died in the period between 1684 and 1686. Cassegrain, like his friend DeBercé, was of Chartres, a city long consecrated to the art of sculpture. At about the same time that DeBercé sent to the Academy of Sciences the little note on Cassegrain's telescope,

Cassegrain himself wrote a long letter to the Academy concerning the speaking trumpet, lately invented by Sir Samuel Morland.

It was in this letter that the writer got the first clew to Cassegrain's identity, since in it he displays beautiful draughtsmanship, as shown in the accompanying copper plate, in striking contrast with his friend's rough sketch, and also a notable familiarity with the art of bell founding, which very likely may have been practised in his own atelier. In fact he writes like an educated and experienced artist, and was obviously regarded as a person of some consequence, for this letter formed the *pièce de resistance* at the meeting of the Academy of Sciences on the 2nd of May, 1672. When and where Cassegrain was born one cannot tell with any certainty, although it is not unlikely to have been somewhere about 1630 to 1635, quite possibly in Chartres. At all events his profession and facilities were such as would very readily have led him towards a reflecting telescope if a hint of Mersenne's suggestion to Descartes, or of James Gregory's theory, had come to his notice.

Note that in the account of Newton's telescope in the *Journal de Sçavans* the word is used in its modern English sense instead of being, as now, confined in French to reflectors, while the Cassegrainian instrument is spoken of as a little "lunette d'approche." One does not generally suggest dimensions for a thing non-existent. Whether Cassegrain actually made and experimented with telescopes nobody actually knows, but as a founder, familiar with bronze and bell metal, it is not unlikely that he tried it.

It was bell metal, by the way, which was the basis of Newton's speculum metal. He merely whitened it a little with arsenic, as the alchemists had done before him thinking the alloy one stage in the transmutation of copper to silver. Bell metal ranged in early times from one part tin to four of copper, to one part tin to two of copper. Newton's was very likely between the two, since he recommends one of tin to three of copper, a material which works and polishes well, but tarnishes with great rapidity, as Sir William Herschel found to his cost many years after.

Exit now the reflector for more than half a century. Newton made one more try at it about 1700, working on a 4-inch glass speculum to be silvered on the back after the plan early proposed by Gregory. The instrument was apparently never completed.

Another item often ascribed to Newton was the discovery of pitch polishing. That he found the process to work well is undeniable, but he did not disclose it for more than thirty years after his little telescope had been laid on the shelf of the Royal Society, in fact not until several years after there had been published, subsequent to Huygens' death, the fact that he had been in the habit of polishing his true tools for lens grinding in exactly this manner.

It was not until Newton was a venerable invalid, a half century after his telescope had been put away and forgotten, that the reflecting instrument was finally put upon the stage by John Hadley, the inventor of the reflecting octant.

Hadley knew enough to make his own speculum metal and in his struggles with it derived very little information from Newton's experimentation. He realized the importance of parabolizing his main mirror and of giving a hyperbolic figure to his small mirror. He polished them both not directly upon pitch, but upon pitch over-laid with the finest silk fabric, which apparently helped in distributing and holding the abrasive, and in 1722 presented to the Royal Society the first veritable reflecting telescope.

This instrument was of about 6 inches aperture and of about 5 feet focal length and proved on test to be better than the telescope of 123 feet focus belonging to the Royal Society and made by Huygens. The tests of the telescope show that it had a pretty good figure, and in fact Hadley hit upon the method of testing for figure used for many years thereafter and still employed, by examining the speculum at the centre of curvature and judging of the parabolic figure by the default of the image from the characteristics of a spherical mirror.

John Hadley, in fact, was the real inventor of the reflector in quite the same sense that Mr. Edison invented the incandescent lamp; from grasping the true principles of the matter and carrying them out to success while the only previous attempts had ended in dismal failure.

It was Hadley who taught the art to Molyneux and others, and to whom James Short, the most celebrated of eighteeneh century artists until the time of Herschel, was undoubtedly indebted for the start upon his brilliant career.

Short, however, worked to the Gregorian principle with success, doubtless since because this telescope rectifies the image, it is available both for terrestrial and celestial use. He made instruments from all accounts of beautiful figure, some of them up to 8 or 10 inches diameter, and of a speculum metal so nicely compounded and polished that some of his specula were still serviceable well toward the end of the nineteenth century.

There is good reason to suspect that Short may have been the inventor of the system of distributed grooves given to the tools, upon which successful figuring so much depends, since, dying, he ordered the destruction of his whole equipment, a quite needless precaution against the success of posterity had there not been very radical improvements, easily detected. James Short, too, was the first constructor of genuine equatorial mountings of which he executed several about the middle of the eighteeneth century. He died leaving the methods which led him to success a mystery unsolved, for Herschel and his successors to puzzle over. Even Herschel left no records of his methods of casting and figuring specula. The only change in the situation after Herschel's day was the independent invention of Steinheil and Foucault which gave to silver-on-glass its present supremacy. The earliest examples of Foucault's work show how little, otherwise than in the material and figuring of the speculum, the art of telescope construction had progressed since Hadley and Short were working a century before.

THE TOTAL ECLIPSE OF SEPTEMBER 21, 1922

By W. W. Campbell*

A NOTE in the October, 1921, number of these *Publications* described the astronomic and the probable atmospheric conditions under which the eclipse of September 21, 1922, will be observable at the Maldive Islands, Christmas Island, the Ninety-Mile Beach on the northwest coast of Australia, and the points accessible by railroad in southeastern Queensland.

It is expected that an expedition from the Kodaikanal Observatory, Southern India, in charge of Director Evershed, will locate in the Madlive Islands.

An expedition from the Royal Observatory, Greenwich, personnel consisting of Mr. and Mrs. Jones and Mr. Melotte, sailed from Liverpool in January for Christmas Island. The observers will arrive there several months in advance of the eclipse date, partly in order to obtain night photographs of the sky needed as reference plates in the Einstein problem, and likewise to conduct a well-considered programme for comparing the brightness of northern and southern stars, with a view to uniformity of the photometric system in the two hemispheres.

The Astronomische Gesellschaft, at the meeting of last summer, formally recognized the desirability of dispatching an expedition to observe the eclipse of this year, and a committee was appointed to consider and provide ways and means. It is now understood that a combined expedition from Germany and Holland, personnel consisting of Dr. Freundlich and Dr. Kohlschütter of Germany, Dr. Voûte of Java and possibly Professor Einstein, will be established on Christmas Island.

As already announced in October, the Lick Observatory had definitely planned to dispatch a modest eclipse expedition to the vicinity of Wallal, the combined telegraph and postal station at the

*In *Publications of the Astronomical Society of the Pacific*, April, 1922.

point on the northwest shore of Australia where the central line of the shadow path intersects the coast line. At that time it was not known that other expeditions would locate in the same region, because the existing means of reaching Wallal were difficult and expensive. Fortunately, some of the Australian astronomers, notably Father Pigot of Riverview College Observatory, Sydney, presented a proposal to the Commonwealth Government that a vessel of the Australian Navy transport the eclipse astonomers and their instruments and supplies from Freemantle, the port of Perth, to Wallal and return, and in due time the Government, with exceeding generosity, offered to provide this service. Upon the receipt of this information, the Lick Observatory, with the approval and financial support of Regent William H. Crocker, enlarged the scale of its expedition as to personnel and instrumental equipment. The plans of the Australian Government in this regard were announced in the United States and elsewhere as effectively as possible, and it is hoped that the opportunities thus provided will be taken advantage of by other expeditions. It is now learned that the Observatory of Perth, Australian, will send a expedition to the Wallal region. The University of Toronto, Canada, is likewise dispatching an expedition to the same destination, the personnel* to consist of Professor C. A. Chant, Mrs. Chant and Miss Chant.

The Observatory at Adelaide has decided to locate an expedition at Cordillo Downs, on the central line of the shadow path in the extreme northeastern corner of South Australia. This location calls for the exercise of courage and patience, in that the transportation of instruments and supplies from the nearest point on railway to Cordillo Downs will consume five or six weeks by camel train.

The Sydney Observatory will send an expedition to Goondiwindi, in the southern part of Queensland, in charge of Director Cooke.

The desirability of repeating the tests for the deflection of stellar rays in passing through the sun's gravitational field at the

**Note added by C.A.C.*:—The expedition will be greatly strengthened by the addition of Dr. R. K. Young, of the Dominion Astrophysical Observatory, Victoria, B.C., who, with the approval of the Director and the Government, will be a member of the party.

eclipse of next September is universally recognized. Although the grouping of the stars on that occasion will not be nearly so favourable as when the British expeditions observed for the Einstein effect in May, 1919, yet the experience gained at the eclipses of 1918 and 1919, suggesting improved equipment and methods, gives promise of entirely satisfactory results, if weather and other conditions prove to be favourable. Accordingly, the Einstein problem is the principal feature of most of the observing programmes. The Greenwich party will observe for Einstein effect with the Greenwich astrographic telescope, mounted equatorially.

The chief and perhaps exclusive feature of the German-Dutch programme is the Einstein problem, but information is not at present available as to the plans for securing the reference night plates of the group of stars concerned.

The Perth astrographic telescope will form a part of the eclipse equipment of the Perth Observatory. It will presumably be applied to the Einstein problem, but information on this subject is lacking.

The personnel of the Crocker expedition from the Lick Observatory will consist of Director and Mrs. Campbell, Dr. Moore and Dr. Trumpler. Volunteer members of the expedition will be Dr. and Mrs. Adams of Wellington, New Zealand, Dr. Baldwin and Mr. Hosking of the Melbourne Observatory, Professor Ross of the University of Western Australia at Perth, and probably one or two others. The equipment devoted to the Einstein effect will be as follows: (*a*) two cameras with Hastings-Brashear quadruplet lenses, clear apertures 5 inches and focal, lengths approximately 15 feet, mounted equatorially, and (*b*) two cameras with Ross-Brashear quadruplet lenses, clear apertures 4 inches and focal lengths 5 feet, mounted equatorially. The sensitive plates in the four cameras will be 17 inches square, of plate glass one-fourth inch thick. It is expected that the four lenses will yield small and round star images, essentially out to the edges of the plates.

Inasmuch as the Navy transport will not be available until late August, and access to the Wallal region by the ordinary transportation systems is extremely difficult and essentially impossible for such heavy equipment, occupation of the station several months in advance of the eclipse date to secure the night

reference plates in not practicable, and it is therefore planned that the night plates shall be secured by Dr. Trumpler on the island of Tahiti, unfavourable incidents not preventing, in May and June, 1922. The mounting of the four cameras consist entirely of steel, brass and cast iron, and they are provided with means of delicate adjustment such that the instrumental conditions prevailing at Tahiti should be duplicated without special difficulty, to the required degree of refinement, at the eclipse station. This proceeding appears to be unobjectional, because Tahiti and Wallal differ in latitude only 2¼° and both are at sea level. The differences in the atmospheric refractions at the two times and places of observation should be extremely small, and eliminate themselves in the least square solution. As a further precaution, however, an auxiliary group of stars located 6 hours east of the eclipse group will be photographed at Tahiti and at Wallal, and the plates exposed to the eclipse group, all exposures occurring at the eclipse latitude.

The equipment of the Toronto expedition consists of a camera with quadruple lens 11 feet in focal length, mounted equatorially. It has been arranged that the night reference plates in Dr. Chant's programme will be secured by Dr. Trumpler at Tahiti. The Toronto camera has been designed that it may be attached to the equatorial mounting used by Dr. Trumpler at Tahiti after securing the Lick Observatory plates.

The programme of the Crocker expedition will further include the photography of the corona, with a camera of 6 inch aperture and 40 feet focal length, in accordance with the Schaeberle method, and likewise with a camera 6 feet in focal length.

The spectrum of the corona, as to its general features, as to the accurate wave-lengths of some of its bright lines, and as to the distribution of several of its gaseous constituents, will be the subject of Dr. Moore's observations with three spectrographs.

The Adelaide Observatory, in charge of Director Dodwell, will be equipped in part with a camera having a quadruplet lens loaned by the Allegheny Observatory for application to the Einstein problem, and further with a camera 40 feet in focal length, loaned by the University of California for the photography of the corona. The interval of time between mid-totality at Wallal and Cordillo

Downs will be 35 minutes, and it is hoped that photographs of the corona secured at the two stations with instruments nearly identical may be valuable in a study of changes in the coronal structure during this interval.

Dr. Cooke plans to apply the Sydney astrographic telescope to the Einstein problem at Goondiwindi.

Plans and instrumental equipment other than those described above are at present unknown.

MEETINGS OF THE SOCIETY

AT WINNIPEG

February 8, 1922.—A meeting of the Winnipeg Centre was held on the above date in the Assembly Hall of the University Arts Building, the President occupying the chair.

Mr. G. P. Morse, C.E., 91 Dubuc St., Norwood, Winnipeg, was elected a member.

The President remarked on the social and conversational meeting held on January 25 in place of the ordinary meeting, saying that the success of the evening was dependent in large measure upon the efforts of the Vice-President, Mrs. E. L. Taylor, and of Mrs. C. E. Bastin. The President expressed the thanks of the Society to these two ladies, and suggested that a similar social evening would be suitable at the close of the season.

Mr. C. E. Bastin gave a short talk on "The Atmosphere of Mars," which was most interesting. According to the planetary hypothesis, Mars is a twin of our earth. Its general climatic nature is similar to ours, and it possesses an atmosphere containing water vapour, like ours, but much less dense.

The lecture of the evening was given by the Rev. T. W. Morton on the subject, "The Spectroscope in Astronomy," of which the following is an abstract:

"Great interest attaches to the use of the spectroscope in astronomy, one particular use of it being in the discovery of the spectroscopic binaries, which are two stars so close together that they cannot be distinguished as separate stars, by means of the telescope alone.

"The first step in spectroscopy was taken by Newton, in obtaining the spectrum, and in then reuniting the constituents to form white light again. In 1802, Wollaston improved the production of the spectrum, by the aid of the slit, and discovered seven dark lines which he took for the boundaries between elemental colours. In 1814, Fraunhofer discovered the myriad number of solar lines. Brewster proved some of these to be due to the atmosphere of the earth.

"Bright line spectra were investigated in 1835 by a Scotchman named Thos. Melville, and the work was taken up by others. The universal presence of the D lines was very perplexing to early investigators, but it was finally explained by testing the effect of very small amounts of common salt, which were shown to produce the D lines.

"Work on bright line and dark line spectra went on separately until the

correspondence between them was discovered. One Miller, and Foucault, obtained dark line spectra. Kirchhoff and Bunsen showed dark lines to be due to selective absorption, and the final proof of this was given by Balfour Stewart.

"Fizeau showed, on Doppler's principle, that the proper motion of stars can be measured by a shift of the spectral lines, and it is the measurement of relative motions in this way that permits the discovery of spectroscopic binaries, in which two stars rotate about a common centre of gravity, giving periodic shifts in the spectral lines."

March 8. 1922.—The President occupied the chair.

The President called on the Secretary to open the discussion on mock suns. The Secretary read an extract from Wood's Optics on the subject, and a letter from Arthur Heming, giving further details of an appearance of this character, recounted by Mr. Heming in the March 1, 1921, issue of *MacLean's Magazine*. Mr. G. P. Morse told of having seen something very similar in Nova Scotia during the month of August. Mr. C. E. Bastin recounted a beautiful appearance of mock suns observed by him one winter in this province, the effects being practically the same as those enumerated in Wood's Optics.

The President called on Prof. N. R. Wilson to give his second lecture on the Origin of the Earth. Prof. Wilson reviewed the two hypotheses as to the origin of the earth, which are the nebular, or Laplacian hypothesis, and the hypothesis recently advanced by Chamberlin and Moulton, known as the planetary hypothesis. The lecture was in the nature of a review and summary of the first lecture given by Prof. Wilson on this subject, and was much appreciated by those present. An important point brought out is that a ring of matter, such as our earth originated from according to the older hypothesis, would not be able to carry away or to retain an atmosphere, such as the earth actually possesses. Concentrated material, however, could carry away and retain an atmosphere, and this point is in favour of the planetary hypothesis.

March 22, 1922.—The President occupied the chair.

The lecturer, Mr. H. M. Guenther, who was to have spoken on "The Effects of Astronomy in Daily Life," had been detained out of town, and the lecture scheduled for April 12th, on "Light Waves and the Measurement of Distances," by the Secretary, Dr. C. D. Miller, was substituted. The following is a summary of the lecture:

"Light has been recognized during recent times as being of a wave-like nature, and the waves of visible light constitute a small range in a general class known as electromagnetic waves. Electromagnetic waves include waves produced by oscillating electrical circuits, such as are used in wireless telegraphy and Hertz waves, infra red 'light' or 'heat' waves, visible light, ultra-violet, X-rays, and the gamma rays from radium. The length of such waves ranges from infinity, down to one billionth (.000,000,001) of a centimeter for the gamma ray waves. From electromagnetic theory, and by simple electrical experiments, the velocity of electromagnetic waves can be shown to be very close to 300,000 kilometers per second. The wave-length of visible light ranges from 75 to 38 millionths of a centimeter. Taking an intermediate value of 50 millionths,

the number of waves passing a given point in one second is the number of times 50 millionths of a centimeter is contained in 300 million meters, or 600 million million. A moving picture machine throws about 25 separate pictures on the screen each second. At this rate it would take such a machine 800,000 years to throw as many separate pictures on the screen, as there are light waves passing a given point in one second. The nature of the medium, called the aether, in which the waves move, is not understood, and its existence is questioned, but no theory seems to offer substitute for the aether, to explain how light travels through space. The velocity of light has been found by direct optical experiment to be 299,900 kilometers per second.

"A method for determining the velocity by reflection from a rapidly rotating mirror was explained.

"Wave phenomena are easy to show with light, particularly interference by reflection from adjacent glass surfaces. A simple type of interferometer was exhibited, which would show the bending in a short stick, due to the weight of a visiting card. The yellow light obtained by putting common salt on the wick of an alcohol lamp was used for this purpose. This light consists of a single wave-length, while white light contains many different wave-lengths and does not work so well. The stick is held rigidly at one end, and at the other it supports a piece of plate glass. A second piece of plate glass is supported from below and brought very near and parallel to the upper piece. An interference pattern consisting of bright and dark bars appears on the reflected image of the flame, and the motion of these bars shows the bending of the stick, a shift of the pattern through the distance from one bar to the next, representing a motion of 29 millionths of a centimeter, or 12 millionths of an inch, in the upper glass, toward or away from the lower glass. Interference of converging rays, obtained by a double slit placed over a telescope objective, was also exhibited. The object viewed was an electric lamp filament, part of which had a bit of green gelatine film in front of it, another part a bit of red, showing the effect of the different wave-lengths of those two colours, in the interference pattern seen in the telescope. Disappearance of the interference pattern for certain distances between the slits, and the relation of this to the measurement of star diameters, were also explained."

Arrangements had been made by Professor MacLean for observation of some of the planets, after the meeting, but weather did not permit of observation. Professor MacLean explained the positions of Jupiter, Saturn and Mars, and said that arrangements would be made at a later date for observing them through the University six-inch telescope.

The meeting adjourned, after which the exhibits arranged by Dr. Miller to illustrate his lecture, were observed by those interested.

C. D. MILLER, *Secretary.*

AT VICTORIA

February 28, 1922.—The meeting was held in the auditorium of the Girls' Central School.

The first part of the evening was taken up by short talks by Mr. W. H. Christie and Mr. W. E. Harper. Mr. Christie, in answering a question as to the cause of the ring around the moon, explained that there were two kinds of rings, the halo and the corona. It is the halo that is usually known as the ring around the moon and it is caused by the refraction of the moon's light through numerous ice crystals suspended in the air. Two sized circles are the most frequent, the one 22 degrees in radius and the other 46 degrees. The orientation of the crystals relative to the horizon determines which halo the observer sees.

Mr. Harper described some of the constellations visible at the present season of the year. These short talks are to form a regular part of future meetings.

The main address of the evening was given by Dr. R. K. Young on "The Spectroscope." Dr. Young described the way the spectroscope was used in astronomy to tell the constitution of the stars. This was due to the presence of certain lines in the spectrum. The position of these lines give the velocity of star and the relative intensity of certain other lines was used to measure the distance. A spectrum of an incandescent light was projected on the screen and the conditions for a pure spectrum explained. A spectrum of a luminous gas was also shown and some of the laws of spectrum analysis enunciated.

The spectroscopes of the Yerkes, Lick and Dominion Observatories were shown by slide and attention called to the salient points in their structure.

March 28, 1922.—Capt. Gerald H. Barry, Shawinigan Lake, B.C., and W. H. Wilson, Duncan, B.C., were elected members.

The main address of the evening was given by Professor P. H. Elliott on Wave Motion. Professor Elliott began his lecture by pointing out that nature affords three means for the transfer of energy from one point to another. The first of these may be called the direct method, where power applied at one point passes by means of a bolt or chain or shafting to another point. The second method is by means of a projectile, the energy in the explosion of powder does work when the projectile strikes. The third method is waves in an elastic medium connecting the two points. The lecturer then proceeded to explain the nature of transverse and longitudinal waves and the elementary terms used in their description, such as period, wave-length, amplitude, crests, phase, etc. He showed a model illustrating transverse waves and a mechanical slide showed how in the compressional wave, the particles moved backward and forward while the point of compression continually advanced. Many of the laws governing the propagation of waves were illustrated by photographs of sound waves from an electric spark. The application to the theory of light in interference and refraction was given and a method of obtaining the wave-length of light from observations of the interference bands between two inclined plates was also given. The lecture was listened to with great interest and was followed by discussions on the nature of the ether and earthquake waves in which several members of the Society joined.

Prior to the main lecture Mr. Duff explained in a very clear and interesting manner the cause of the "old moon in the new moon's arms." He first showed both from the kinetic theory of gases and from occultations of stars that the

moon has practically no atmosphere and that, therefore, the diffuse light could not be due to refractions of light from the bright side of the moon. By means of a slide he showed how the light of the earth was reflected back on this portion of the moon and he referred to the extraordinary sensitiveness of the human eye in being able to detect light thus twice reflected.

Mr. Christie gave a very interesting talk on "How I Photograph Sun Spots with a Three-inch Telescope." As a matter of fact Mr. Christie said his telescope was only two and one-half inches. The telescope has only the alt-azimuth mounting but by a suitable device the spots were referred to the sun's axis and equator and their position, area and character studied. Mr. Christie is to be congratulated on the work he is doing with his very modest equipment.

R. K. YOUNG, *Secretary.*

AT LONDON

April 4, 1922.—The regular April meeting was held in Room 4, Western University, at 8 p.m. on the above date. Dr. Kingston, the President, presided.

The following were elected members:

F. W. Daly, 89 Ridout St.; W. F. Boughner, 294 Wolfe St.; Miss A. I. M. Kittermaster, 236 St. George St.; Mrs. J. W. Brown, 218 St. George St.; and Mr. W. B. Richardson, Grand Ave.

Dr. Kingston gave an explanation of certain parts of pages 34 and 35 of the *Observer's Handbook* for 1922. Slides were used to show how to determine the positions of the moons of Jupiter by means of the Handbook, and also to explain the meaning of the "minima of Algol."

The Secretary then gave an illustrated address on "The Moon." The following topics were dealt with: the size and distance of the moon; the motions of the moon; its phases; eclipses, and how tides are caused. The moon's phases and eclipses were illustrated by lantern slides. Slides were also used to show the most striking features of the moon's surface, such as the so-called seas, the ring craters, the walled valleys and mountains, etc.

Before the meeting closed type-written lists of books on Astronomy to be had from the University Library, and which had been prepared by Dr. Kingston, were distributed to those present.

E. T. WHITE, *Secretary.*

AT TORONTO

March 14.—The Society met in the Physics Building at 8.15 p.m., Prof. C. A. Chant, in the chair.

The chairman spoke briefly of the popular course of lectures on Meteorology, and then called upon the president, Mr. W. E. W. Jackson, M.A., to give the final lecture of the series, his subject being "The Magnetism of the Earth".

The lecturer gave a summary of the history of Magnetism from the discovery of the natural magnet or "lodestone" in the Grecian age, to the time of Gauss, who during the first quarter of the last century placed the science upon its mathe-

matical basis. The properties of magnets were explained; and it was shown that to definitely determine the earth's magnetism at any point, it is necessary to measure the three magnetic elements at that point, namely, the declination, the dip or inclination and the intensity of the force. Usually the horizontal component of the force is measured, from which the total force may be easily deduced. The instruments used in the work of the magnetic observatory were exhibited and their methods of operation described. Besides the ordinary Dip Circle of the Dover pattern, the more sensitive Earth Inductor was explained. This instrument works upon the principal that a moving coil in virtue of the earth's magnetic field has induced in it a current of electricity which may be detected by a galvonometer. If the coil is placed in a particular position, so that its axis of rotation is parallel to the angle of inclination, then the galvonometer shows no deflection, and by this means the inclination is determined very exactly. The sensitiveness of this instrument was demonstrated.

It was very interesting to see the identical instruments brought out from England in 1839 when the Magnetic Observatory was first established here, side by side with the latest pattern of magnetometer, designed at the Carnegie Institution of Terrestrial Magnetism, Washington, D.C. The magnetometer as invented by Gauss consisted of two parts, two pieces of apparatus, and it required a full hour to perform the observation for intensity. Now, however, using the combined magnetometer of the Carnegie Institution, the observation may be made in 12 to 15 minutes, and with the same accuracy. Gauss's method has never been improved upon during the past century. In conclusion, the relation of magnetic storms to aurorae and sun-spots was discussed by the lecturer, and a number of interesting slides of these phenomena shown.

The average attendance for each of the last three meetings has been estimated at 200, which shows that the public are interested in the work of the Meteorological Office.

March 21, 1922.—The President occupied the chair.

Prof. A. P. Coleman, F.R.S., of the University of Toronto, gave a most interesting and instructive address upon the subject "Ancient Ice Ages." "We are living," Prof. Coleman said, "in an exceptional age, for we have winters. The history of the world is known more or less exactly, for a very long time, and it is certain that during the greater part of that time the earth had a mild climate. It is very probable that we are living in the latter part of a glacial age and approaching an inter-glacial period."

To gather evidence on this point, the lecturer visited Spitzbergen, within twelve degrees of the North Pole. At the present time the only trees growing there are minute ones three inches high; but the sandstones on the mountains, 3,500 feet above the sea-level, contain fossil leaves which proves that in some remote period Spitzbergen had a luxuriant vegetation and was covered with forests. Similarly on the Antarctic continent, where the vegetation now consists of a few specimens of lichens and mosses, the presence of coal deposits indicates that the continent some time in the past had a mild climate.

The lecturer then discussed the work of glaciers, showing that the finding

of isolated boulders or erratics, stratified rocks and rock surfaces, or boulder clay, is perfect evidence of glacial action. Many slides were shown illustrating the boulder clays and moraines formed by the glaciers which covered Ontario in the Pleistocene Age.

The lecturer then spoke of his discoveries in South Africa, Australia, Asia and South America, which prove that the Ice Ages affected the whole world and that the glaciers were not confined to the polar regions. The evidences as found in Brazil, latitude 20 s., and at Hyderabad, India, latitude 19 n., were stated to show that the countries within the tropics were affected.

The lecturer briefly explained some of the theories which attempt to account for the Glacial Ages, none of which, however, are entirely satisfactory.

April 4, 1922.—The President occupied the chair.

The following were elected members of the Society:

J. D. Falconbridge, M.A., LL.B., K.C., Chestnut Park Road, Toronto; John Greenshields, 98 Sparkhall Avenue, Toronto; E. S. MacDonald, South Lancaster, Ont.

The lecture was given by Mr. J. F. Heffron on the subject, "Astronomical Science and Modern Philosophy." In this paper Mr. Heffron gave a popular account of the Einstein theory of relativity. The lecturer explained that the theory accounted perfectly for the retrograde motion of the perihelion of Mercury, and further made two predictions: firstly, that a ray of light has weight (which was verified by the Eclipse expedition of May, 1919), and secondly, that there is a shifting of the lines in the Solar Spectrum towards the red end, which, however, has not yet been verified.

The lecturer described the method of photographing the eclipsed sun to determine the shifting of the stars' light in passing the sun and gave the observed values of this displacement as determined by the British astronomers. These values agree sufficiently closely with Einstein's predicted ones that his hypothesis must be accepted. The situation is somewhat disconcerting to scientists as it leads to the conclusion that light has weight and therefore our conception of the ether must be changed. It may be that we may have to again adopt Newton's theory of light in some modified form.

The lecturer gave some interesting illustrations of space, time and the fourth dimension which is expressed by time in Einstein's theory. The questions of space and time have occupied the minds of philosophers for over 2,400 years. It is interesting to note that Kant concluded that space and time have no existence apart from the mind. If this is so, many problems, such as life before birth and after death, become meaningless.

A letter was read from Mr. John A. Paterson, K.C., stating that the widow of the late Percival Lowell had transmitted to him for presentation to the Society's Library three volumes written by her late husband, entitled *Mars and its Canals*, *Mars as the Abode of Life* and *The Soul of the Far East*, each bearing the inscription: "To the Royal Astronomical Library of Toronto, in memorial of its author, my husband, Percival Lowell.—CONSTANCE S. LOWELL, 1922."

On motion of Prof. C. A. Chant, seconded by A. F. Miller, the following resolution was adopted: "That this meeting express its high appreciation of the gift to the Society's Library by Mrs. Constance S. Lowell of the three volumes entitled: *Mars and its Canals*, *Mars as the Abode of Life* and *The Soul of the Far East*, written by her distinguished husband, the late Percival Lowell."

A letter was read from Mr. T. S. H. Shearmen, Meteorological Observer at Victoria, B.C., describing an extraordinary meteoric display seen at Duncan, B.C., on December 17th, 1921. Two large meteors slowly drifted across the sky from east to west, brightly lighting up the landscape.

A letter was read from Mr. H. B. Collier, of Viking, Alberta, describing in detail the fine halo around the sun on March 20th, 1922. A sketch of this halo as seen at Garden Plains, Alberta, by Mr. B. S. Wimbush was exhibited, and this agreed perfectly with Mr. Collier's description.

J. A. PEARCE, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE

MARCH, 1922

Temperature

The temperature was above the average in all portions of the Dominion except in British Columbia and the eastern part of Nova Scotia. The positive departures varied from two to nine degrees. The area of greatest departure extended from Saskatchewan to the Lake Superior District. The chief negative departure occurred in Northern British Columbia and amounted to three and a half degrees.

Precipitation

The precipitation was below the average in British Columbia except at a few scattered points where it was slightly exceeded. In Alberta it was less than usual while in Saskatchewan and Manitoba it was in nearly all places above the average In Ontario in, a few parts of the Peninsula, and locally in the Lake Superior District, there was more than the average amount; elsewhere there was less than the normal. In Quebec and the Maritime Provinces it was below the average, and in many parts to a considerable extent. A few of the chief positive departures were: Minnedosa and Toronto one inch. Some of the marked negative departures were: Vancouver, 2.70 inches; Parry Sound, one inch; Montreal, 2.10 inches; Quebec, 1.60 inches; Yarmouth, 3.10 inches; Sydney, 2.90 inches; Charlottetown, 1.50 inches.

SEISMOLOGICAL NOTES FOR MARCH, 1922

Victoria recorded eight disturbances during the month and Toronto six. The largest occurred on the 10th, Victoria trace amplitude showing 3 mm. and Toronto 0.8 mm. The centre of

this earthquake was probably in Northern California. The P waves at Victoria were recorded at 11h 27m 36 s, and the Maximum at 11h 29m 12s. Small microseisms masked the preliminary waves of this record at Toronto, but the Maximum was recorded at 11h 41m.

J. Y.

TEMPERATURES FOR MONTH OF MARCH 1922

STATIONS	Highest	Lowest
Yukon		
Dawson	30	—40
British Columbia		
Atlin	38	—12
Agassiz	59	27
Barkerville	41	— 6
Kamloops	59	11
New Westminster	58	29
Prince Rupert	46	26
Vancouver	55	29
Victoria	57	33
West Provinces		
Battleford	50	—15
Calgary	52	—14
Edmonton	52	—10
Medicine Hat	58	0
Minnedosa	44	—15
Moosejaw	46	—17
Oakbank	47	—18
Portage la Prairie	..	..
Prince Albert	46	—30
Qu'Appelle	46	—16
Regina	40	—25
Saskatoon	40	—14
Souris	46	—16
Swift Current	46	—30
Winnipeg	49	—10
Ontario		
Agincourt	55	10
Oak Ridges	51	8
Bancroft	46	— 9
Barrie	49	6
Beatrice	46	— 9
Bloomfield	55	2
Brantford	56	14
Chapleau	45	—22
Chatham	..	..
Clinton	64	9
Collingwood	52	10
Cottam	..	..
Georgetown	52	10
Goderich	59	11
Grimsby	59	14
Guelph	54	9

STATIONS	Highest	Lowest
Ontario—cont.		
Haliburton	48	—14
Huntsville	50	—14
Kenora	44	— 8
Kinmount	50	— 6
Kingston	54	6
Kitchener	56	10
London	65	10
Lucknow	65	2
North Gower	50	— 5
Oshawa	..	..
Ottawa	56	— 4
Paris	57	12
Parry Sound	46	0
Peterborough	56	— 4
Port Arthur	50	4
Port Dover	55	13
Port Stanley	52	14
Queensborough	48	— 1
Ronville	46	— 2
Southampton	60	11
Stonecliffe	..	..
Stoney Creek	58	14
Toronto	58	13
Uxbridge	52	— 1
Wallaceburg	..	..
Welland	64	11
White River	45	—27
Quebec		
Brome	..	..
Father Point	48	— 4
Montreal	54	4
Quebec	50	— 6
Sherbrooke	59	— 1
Maritime Provinces		
Charlottetown	48	— 2
Chatham	54	—12
Fredericton	56	—20
Halifax	54	— 2
Moncton	53	—10
St. John	52	— 2
Sussex	53	15
Sydney	44	— 2
Yarmouth	48	6

BOOK REVIEWS

Annual Report of the Director of the Mount Wilson Observatory for 1921

This report extends to eighty pages and deals with so many subjects in a comprehensive but very concise way that it is extremely difficult to summarize it. There is hardly an astronomical subject of importance which is not being attacked at Mount Wilson in a powerful way.

Dr. G. E. Hale, the director, mentions three outstanding events in the past year's history of the observatory. The first is the publication of the absolute magnitudes and parallaxes of 1646 stars and important generalizations therefrom. The second is the application of the interferometer to the measurement of star diameters. The third is the establishment in Pasadena of the Norman Bridge Physical Laboratory. This latter institution is a part of the California Institute of Technology, and with the Gates Chemical Laboratory of the same institution will unite with the Observatory in astrophysical work. May we soon expect to find the solution of the mysterious lines in the spectra of the corona, the nebulae and the aurora?

But it is simply impossible to give even a list of the problems under investigation, much less to state the progress which has been made in them. Iu most cases they are of fundamental importance and the results ultimately obtained will settle many theories as to the nature of various celestial bodies and their phenomena.

Dr. Hale states that for many years visitors have been admitted daily to the Observatory Museum of Astronomical and Physical Photographs on Mount Wilson and to certain of the instruments. During the year about 10,000 visitors inspected the great 100-inch telescope. Following out a long-projected desire to give an evening each week to the public for observation it has been arranged

that visitors will be admitted to use the 60-inch reflector on Friday evenings. Tickets are issued without charge to those who apply at the office at Pasadena. C. A. C.

Gnomonique, ou Traité théorique et pratique de la construction des Cadrans solaires: par G. Bigourdan, Membre de l'Institut. 214 pages, 5½ x 9 in., 104 figures, Paris:Gauthier-Villars, 1922, in paper price, 10 fr.

Watches and clocks are now so cheap and so generally used that sun-dials are not so necessary in the life of the people as they were in former times, though even yet in isolated places the dial is very useful for regulating the clock. But in earlier times they were very common and specimens of various types and dimensions have been preserved. A writer of the 16th century remarks that consulting the sun-dial was almost as necessary as eating and drinking. In the 18th century writers of the time state that every house had its dial and workmen specially devoted to constructing them were easily found. To-day many of the small instruments are eagerly sought by collectors and some of the larger dials still form elegant features in schemes of architectural decoration or in ornamentation of gardens.

To all who are interested in these instruments Mr. Bigourdan's little volume will be of great utility. He first gives a brief historical sketch indicating the gradual passage from the primitive gnomon to the sun-dial, and then deals with the theory of these instruments of sizes and types so varying: equatorial horizontal, azimuthal, analemmic and other kinds of dials. Then the manner of mounting and the determination of the meridian and of latitude is explained. The volume ends with tables giving the angles in dials of different kinds, and also the dates of Easter and of the movable feasts over a long period of years. The illustrations are numerous and interesting. C. A. C.

THREE CANADIAN PUBLICATIONS GIVING MAGNETIC MEASUREMENTS

1. *Magnetic Observations in Western Canada*: Bulletin No. 46 of the Topographical Survey Branch, Department of the Interior, by W. H. Herbert, B.Sc.

The principal part of the bulletin is a catalogue of over 13,000 observations for declination taken during the period 1908-1918 at 9,374 stations distributed throughout Western Canada, the observations being made with the magnetic compass attached to the transit. The information given includes: locality, longitude, latitude, location of station, date, declination and observer.

The second part of the report contains the observations taken at 317 repeat stations to determine the secular changes in the three magnetic elements. The variation in declination is shown graphically for 56 stations. The earliest observations stated are those made on the shore of Hudson Bay at Fort Albany in 1668, and at York Factory in 1725.

The third part consists of the observations for the three elements taken during 1908-1920 at 250 stations. A description of each station is given.

Isomagnetic charts for the epoch 1917.0 accompany the bulletin.

2. *Magnetic Results, 1907-1920*: Volume V, No. 5, Publications of the Dominion Observatory, by C. A. French, B.A.

The report summarizes the work of the Magnetic Survey for the period 1907-1920, giving all the observed values of the magnetic elements and their corresponding values reduced to the epoch 1921.0. The report contains the description of the instruments employed, the methods of observing, the reduction of observations to International Magnetic Standards, the reduction to the epoch 1921.0, secular change data, and a very complete description of each station. In all 640 stations throughout Canada were occupied, of which 424 were distinct localities and 216 were repeat stations.

The observations are published in two sections: the first, dealing with secular change, gives the observed value at each of the repeat stations; the second section consists of the tabulated values of the elements and their corresponding reduced values.

A map of Canada, indicating at a glance the value of the declination at every station, reduced to 1921.0, accompanies the report.

3. *Results of Observations at the Canadian Magnetic Observatories, Agincourt and Meanook, for the Year 1918*, by W. E. W. Jackson, M.A. (Publication of the Meteorological Service).

The report consists of 38 tables containing the following information:

The observed and adopted value of the photographic base-line reduced to International Magnetic Standards for declination, horizontal force and vertical force. The observations for declination and horizontal force were taken weekly, while those for vertical force were taken twice a week with a Toepfer earth inductor.

Mean, D, H and Z for each day of the year.

Diurnal inequalities of D, H and Z, analyzed harmonically, for each month.

Monthly and yearly means of D, H, Z, X, Y, I and F.

Twenty-eight of the tables refer to the observations taken at Agincourt and the remaining ten refer to those of Meanook.

Copies of the photographic curves obtained on 12 disturbed days are reproduced, 48 curves in all.

J. A. P.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

QUERY

I note a paragraph in the local paper referring to the star that flared out so brightly in Perseus near Algol in 1901. This paragraph says that the aforesaid star is showing signs of renewed brightness. Is this so?—B. S. WIMBUSH, Garden Plain, Alberta.

ANSWER

When discovered by Anderson, of Edinburgh in the early morning of February 22nd, the nova had a magnitude of 2.7, and two days later it reached a maximum of 0.0 magnitude. Its light rather quickly diminished, with many fluctuations, becoming the 6th magnitude on April 21st, 1901, and since that date it has not been a naked-eye star.

In the British Astronomical Association's *Journal* for December 1921, W. H. Steavenson summarizes Prof. E. E. Barnard's observations on the star during recent years, and from this article the following values are taken:

Year	Highest Max.	Lowest Min.	Mean for year
1916	12.5	14.3	13.6
1917	12.4	14.4	13.6
1918	12.8	14.5	13.8
1919	12.6	14.4	13.5
1920	12.7	14.1	13.5
1921	12.2	13.4	12.7

While it would appear that the mean magnitude of the nova in 1921 was higher than that of the five previous years, it is still a faint object, and even if it should continue to increase in brightness, it would be a considerable time before it becomes visible to the naked eye.

J. A. P.

A SOLAR HALO SEEN BY TWO OBSERVERS 70 MILES APART

Mr. H. B. Collier, of Viking, Alberta (long. 112°, lat. 53°N.), writes:

"On March 20th a very fine compound halo was seen at Viking, Alberta. The aftermath of a big storm in Manitoba and Saskatchewan some two days previously, no doubt, assisted in the production of this solar phenomena.

"The sun shone brightly all day, a slight haze and light clouds being noted. At about 4 p.m. mock suns or parhelia appeared to right and left of the sun, about 22½ degrees apart. These mock suns were so bright, their flaming orange tails so dazzling, that the eye could not withstand the glare for more than a moment at a time.

"The circle about the sun proper, intersecting the mock suns, was crowned with an inverted arc. For a considerable distance along the united portion the brilliant tinted light approached in glory that of the parhelia. Virtually the sky revelled in the glory of four suns for the space of an hour and a half.

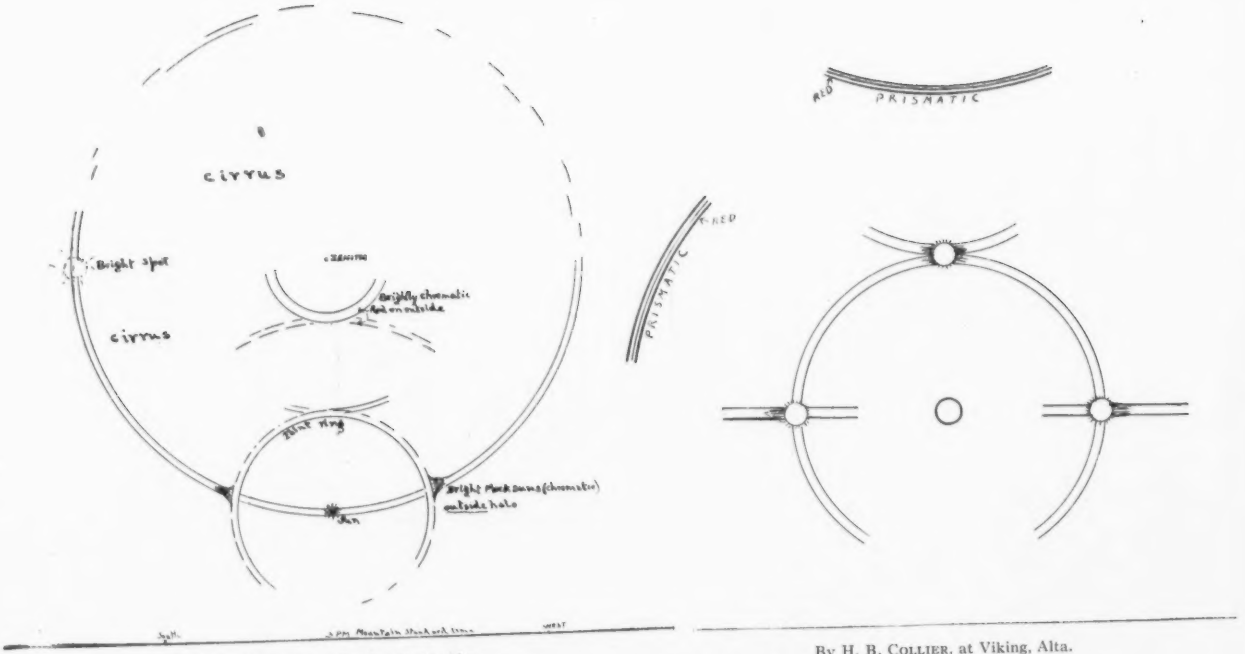
"About 25 degrees eastward from the sun a prismatic arc of some 20 degrees in length glowed. The curvature of this arc showed the sun to be the centre of the circle.

"A still brighter spectrum appeared in an inverted arc high in the heavens immediately above the sun. Each colour flamed out brilliantly under such a powerful sun.

"Both spectra presented the red side to the sun, the violet being on the side of the prism opposite."

Mr. B. S. Wimbush of Garden Plain, Alta. (long. 112°W., lat. 52°N.), sends the following account of the same solar halo:

"It was very wide and brilliantly coloured. The bright spot to the E.S.E. was 90 degrees from the sun on the horizontal band. This band was blurred on both edges, unlike the halo circle which was fairly sharp on the inside. It is also noticeable that the red is always nearest the sun. The aurora was very bright the night before, and there were great fluctuations in the temperature."



By B. S. WIMBUSH, at Garden Plain, Alta.

By H. B. COLLIER, at Viking, Alta.

A solar halo as seen by two observers in Alberta, on approximately the same meridian and 70 miles apart. March 20, 1922.

AUDIBILITY OF THE AURORA

In *The Globe* (Toronto) of March 24th there appeared an editorial discussing the old question of the audibility of the aurora. The writer referred to an address before the Royal Geographical Society by G. M. Gathorne-Hardy, who claimed that he heard a sound accompanying the aurora seen in Labrador in the autumn of 1920.

This brought forth a series of letters to the editor from many persons who claimed that they had heard the sound, and the correspondence showed the wide-spread interest in the matter. The present writer has been collecting evidence on the question for some years and he published a request that any others who thought they had heard the sound and who did not wish to write to the newspaper would send a statement of their experiences to him. A number of interesting letters have been received. These will be discussed later, and extracts from them will be published.

C. A. C.

The Royal Astronomical Society of Canada

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This very scarce pamphlet, printed privately in 1863, was republished in the JOURNAL of the R.A.S.C. and can be obtained in a book of 126 pages. The work discusses the Year of the Pleiades and various questions relating to old calendars. It is of special interest to astronomers, anthropologists and ethnologists. Price $1.00, post-paid.

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